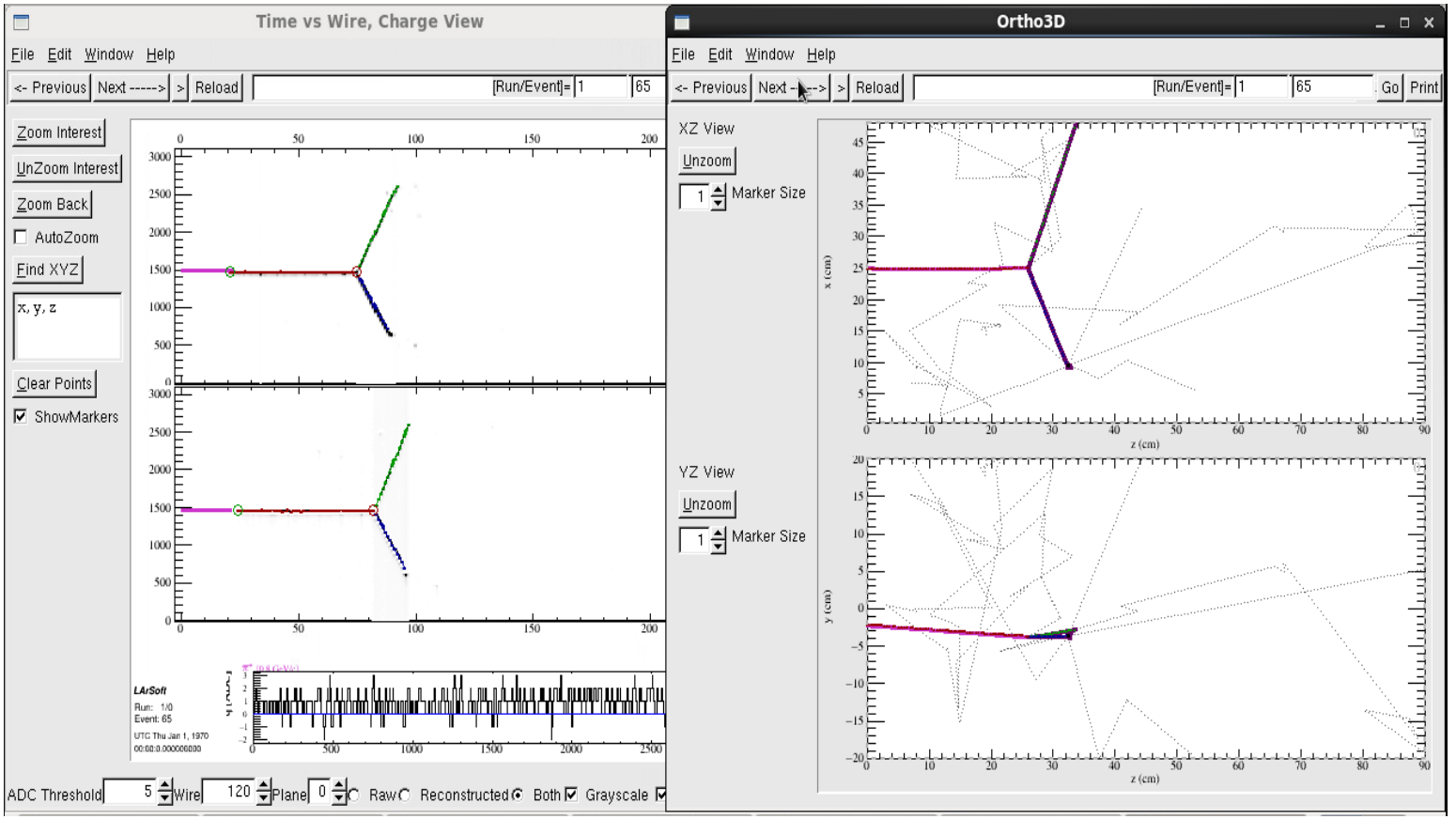
Pion Absorption Analysis Progress



Andrew Olivier
Louisiana State University

Analysis Strategy

- Ultimate Goal: Measure pion absoprtion cross section using LArIAT data
- Goal for next Tuesday: Demonstrate automated reconstruction and identification of pion absoprtion events in MC sample
- Generate large Monte Carlo sample of pions, muons, protons, and kaons to test efficiency and purity of absorption identification
- Identify absorption events by topology:
  - Identify incoming pion
    - Incident energy
    - Must be inside beam window
  - Incoming track contained in TPC
  - Find interaction point candidate
    - No previous scatters off of nuclei
    - One pion entering; no MIPs leaving
    - At least one photon conversion length from end of TPC
  - Require no electron showers

Software Requirements for Analysis

- MC sample: done, but would like to use beam profile and updated SimWire
- PID: needs work
- Hit finding, clustering, and track finding for finding vertex, PID, and checking pion position: done
- Vertexing for identifying absorption candidates: needs work, but can be handled in analysis if needed
- Time scale: Have pion absorption event identification working by Friday

Simulation Configuration

- Taken mostly from prodsingle_lariat.fcl on lariatsoft develop branch
- Based on lariatsoft v01_07_00 e7:prof:noifdh
- Simluation:
  - Prodsingle generator:
    - P0~Uniform(0.3GeV/c, 0.8GeV/c)
    - Z0 = -39.5388cm (Front flange from gdml file)
    - Using random seed generator since multiple jobs run at once
  - SimWireT1034
    - Modified to subtract pedestal mean calculated from ADC bins for each wire
    - Similar to Johnny's implementation on develop, introduce bias when hits are present
    - Similar to FragmentToDigit Algorithm?

Reconstruction Chain

- Reco_MC.fcl
  - lariat_calroi
  - gaus_hitfinder
  - standard_clustercrawlerhit
  - standard_clustercrawler
  - standard_linecluster
  - standard_cosmictracker
  - standard_pmalgtrackmaker
  - standard_cctrackmaker
  - standard_calomc
  - standard_chi2pid
  - lariat_primaryvertex

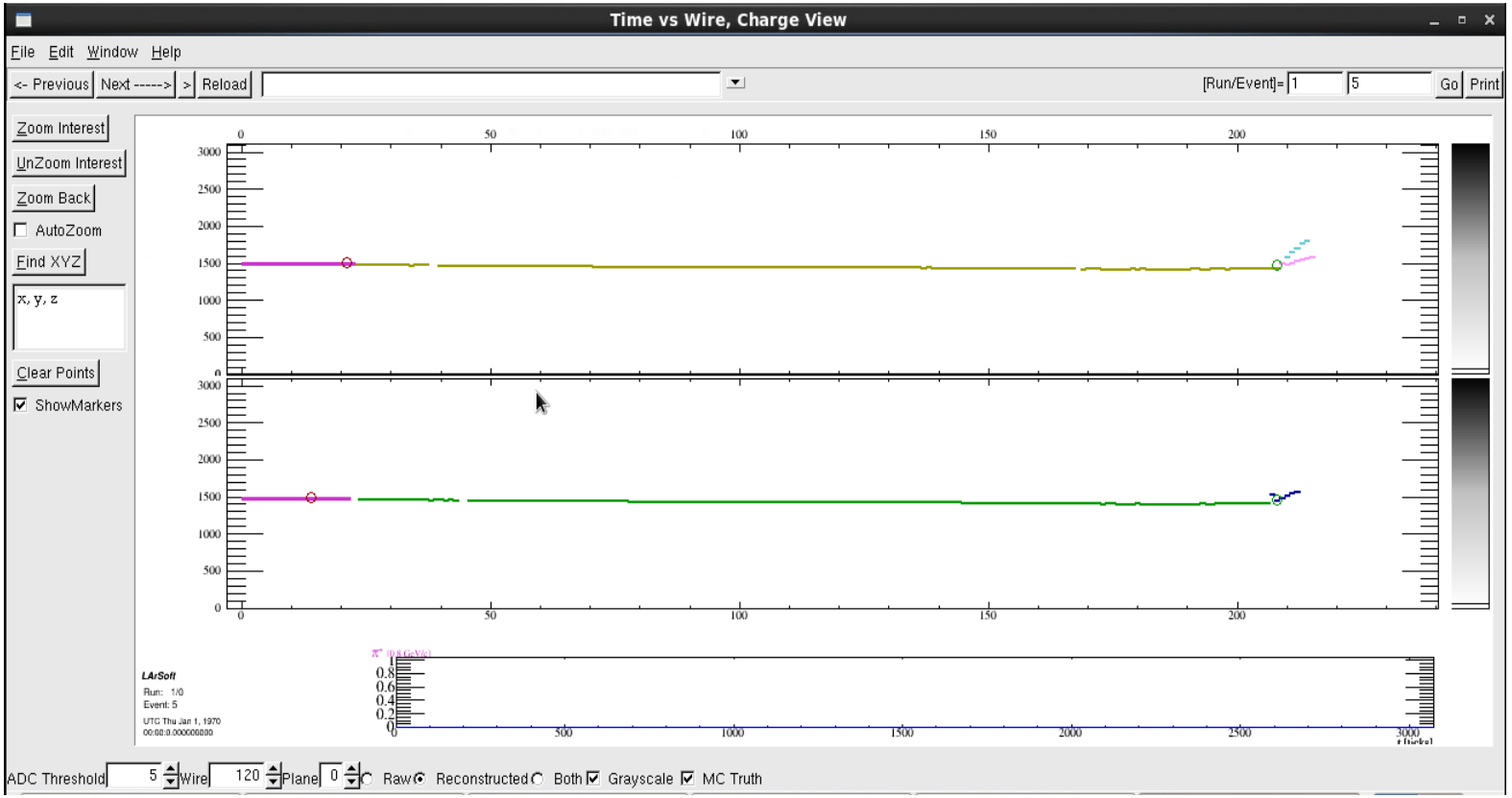
Hit Finding

- gaus_hitfinder from Reco.fcl
- Hits look reasonable, but not sure whether bias introduced in raw digits distorts signals
- Offset very sligthly in time versus wire dipslay

Clustering

- Based on standard_linecluster from Reco.fcl
- KinkAngCut set to [0.2, 0.2, 0.2] to improve cluster splitting efficiency for small kinks
- Seems to identify reasonable clusters, but misses apparent tracks altogether in rare cases
- Many events have no data products from cluster crawler related analysis

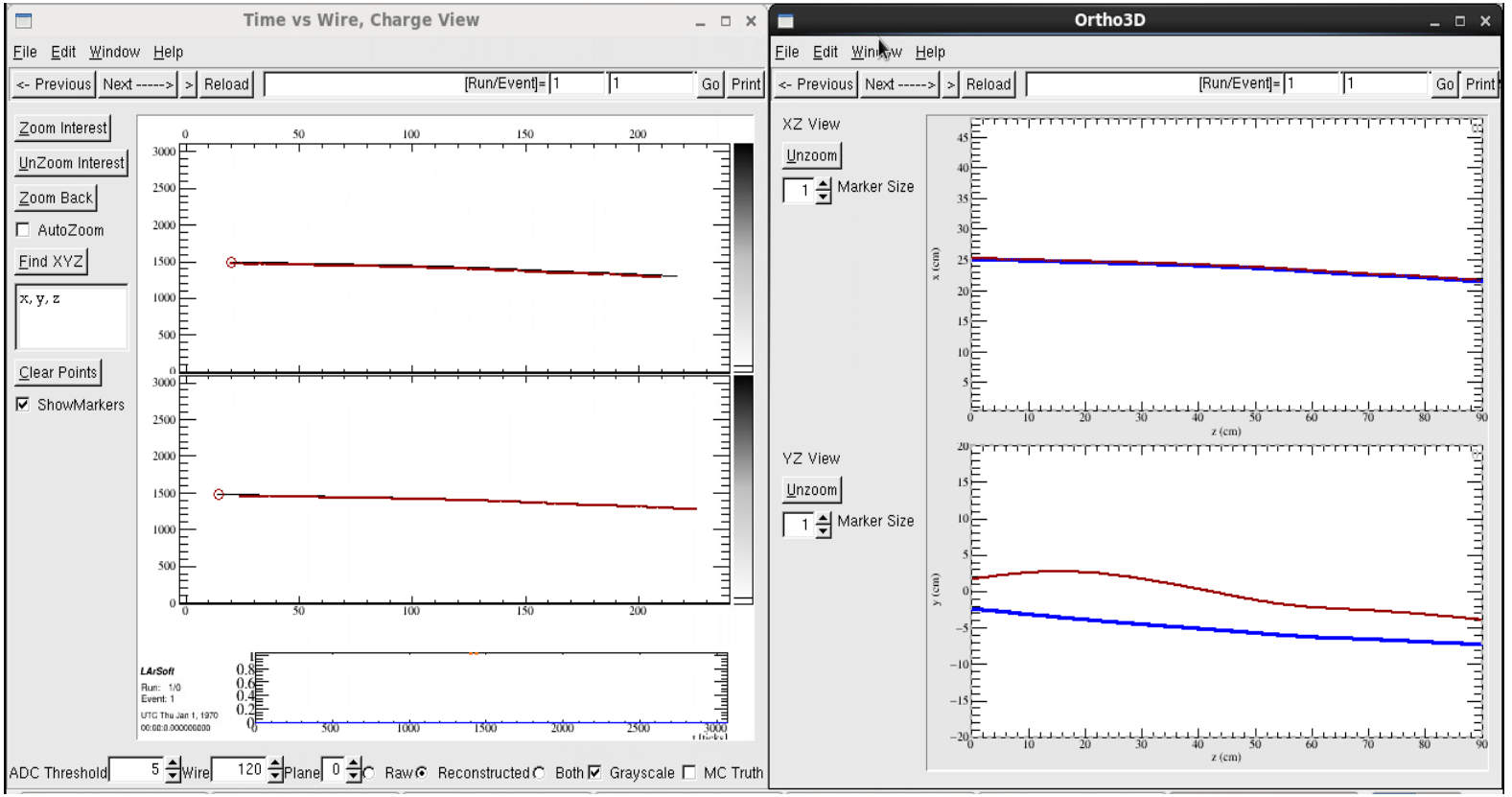
Example of Clusters with Vertices



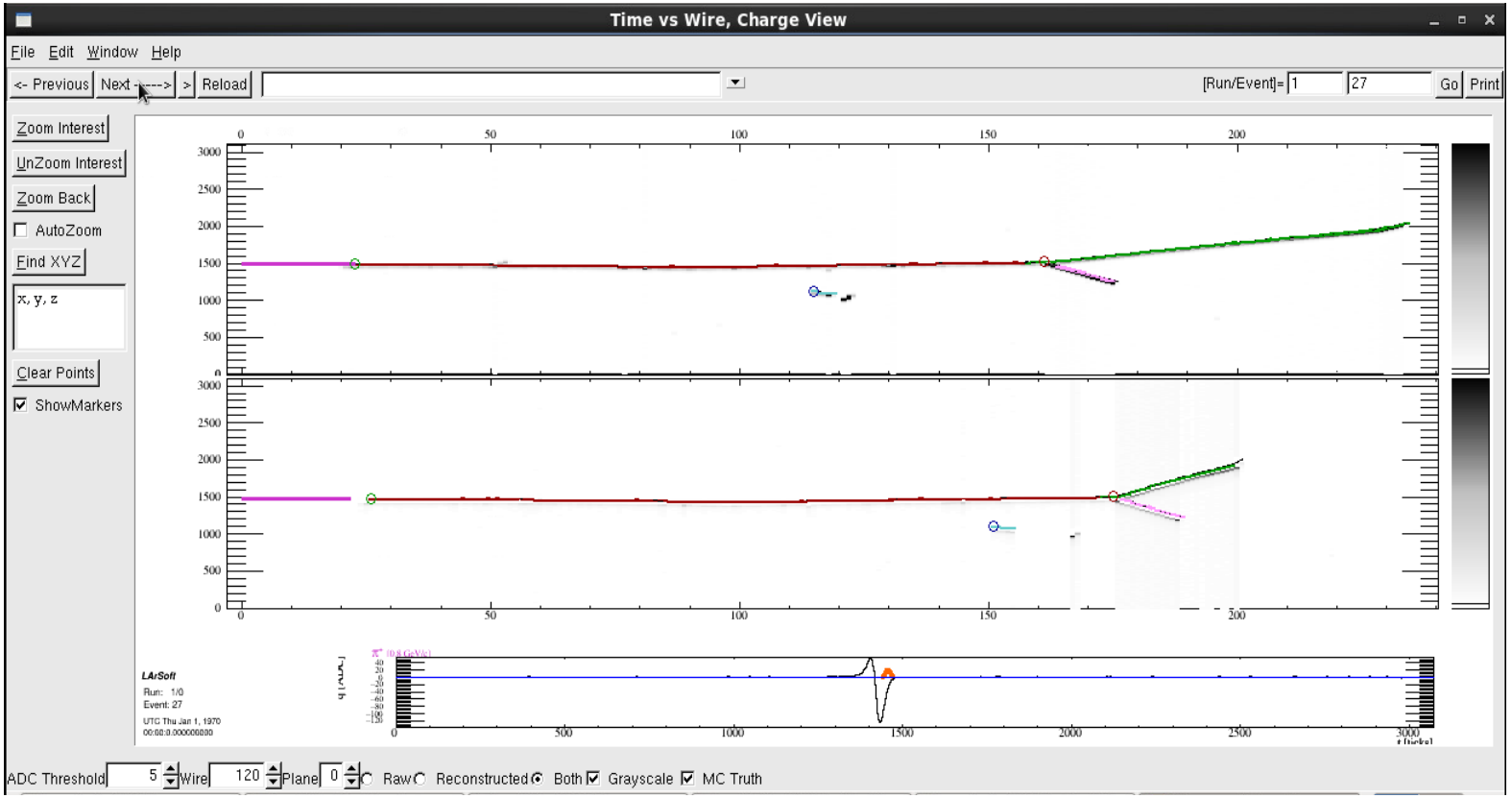
Tracking

- standard_pmalgtrackmaker
  - AutoFlipdQdx and FlipToBeam set to true to facilitate vertexing
  - TimeOffsetV from DetectorProperties set to 0 at Tingjun's reccomendation. This fixes offset in y direction.
  - Seems to be best track module in Reco.fcl with these changes
  - Not sure how to get vertices from this module
- Often get no data products from cluster crawler tracker

PMTrack Before TimeOffsetV=0



Example of Tracks with Vertices



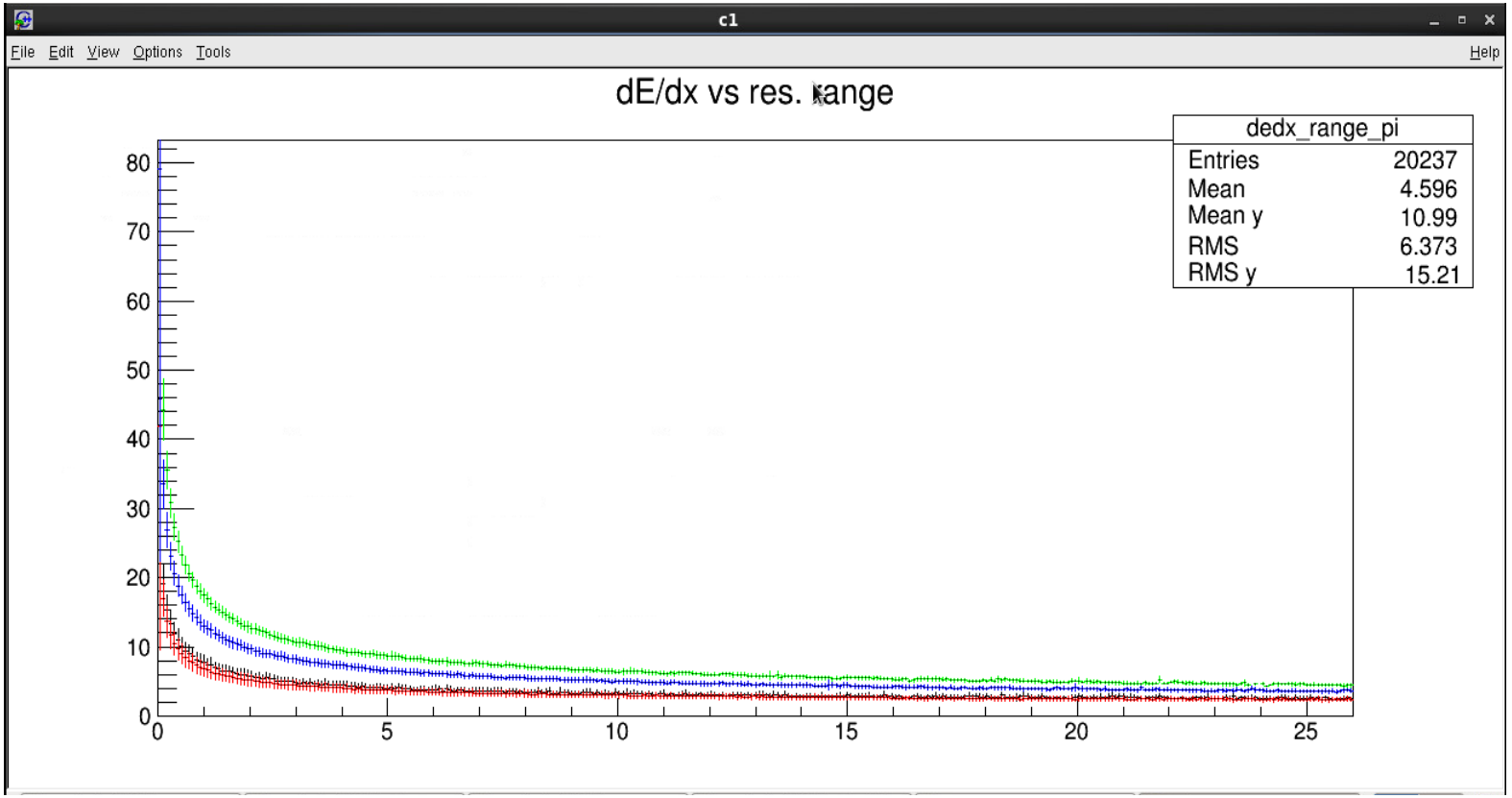
Identifying Vertices

- lariat_primaryvertex
- Modified with help of Brian Rebel to produce vertex to track associations
- Currently seems to only match one vertex per track. Should this be changed?
- VertexWindow set to 5 cm
- Currently seems to create vertices in correct places with most of correct tracks associated, but will only associate each track to one vertex

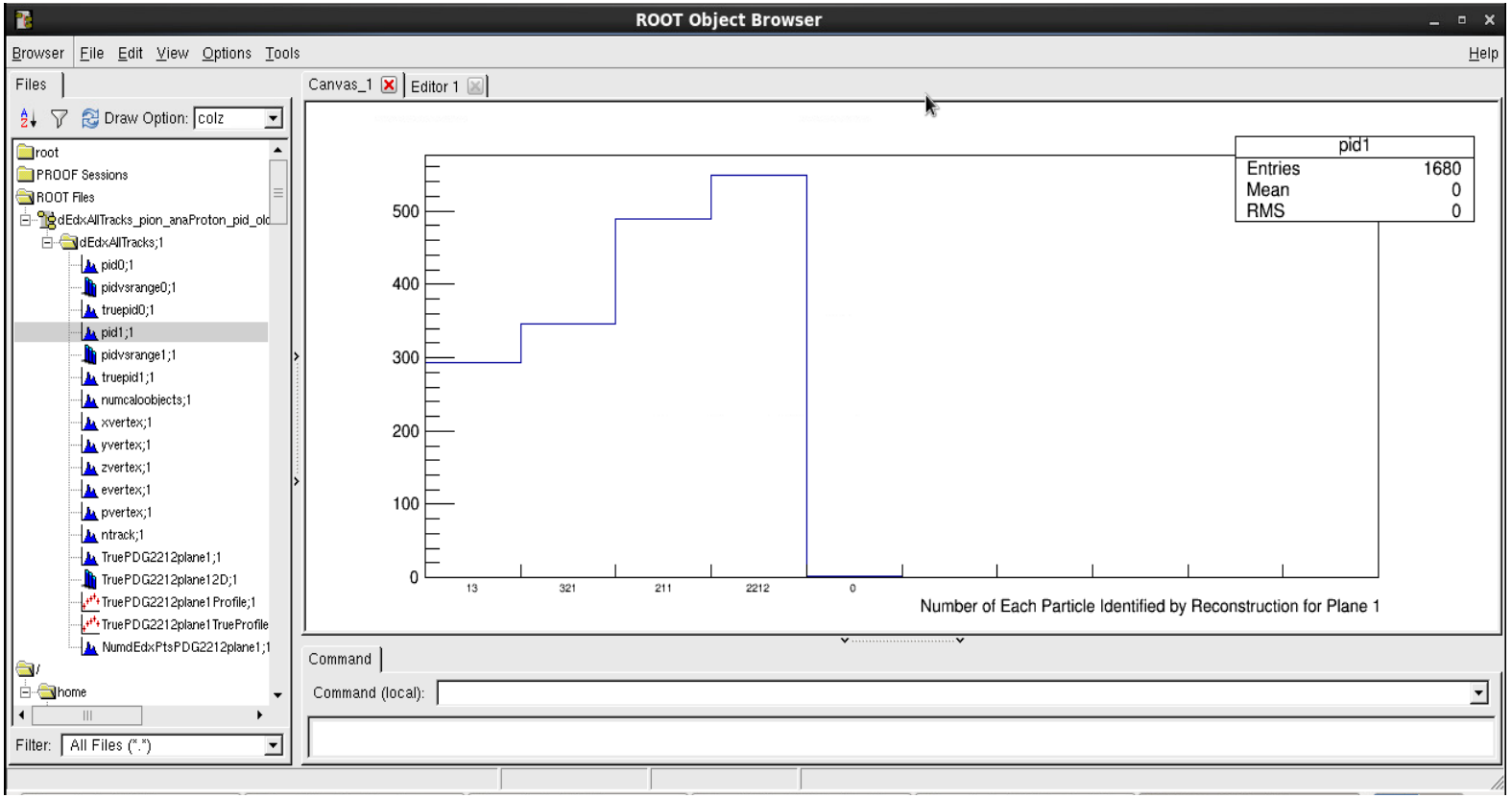
Calorimetry

- standard_calomc
- Same parameters as non-MC calo on develop in v01_07_00
- Currently producing results not consistent with dE/dx versus residual range plots in lardata
- Tested several different TemplateFiles

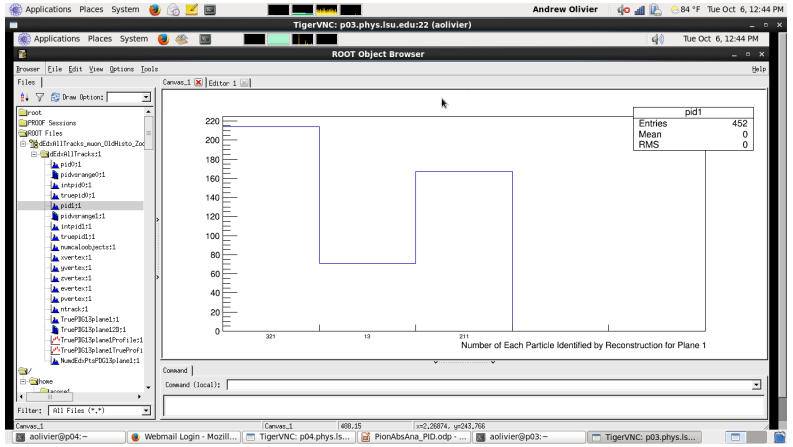
larsoft_data dE/dx Vs. Residual Range Plots



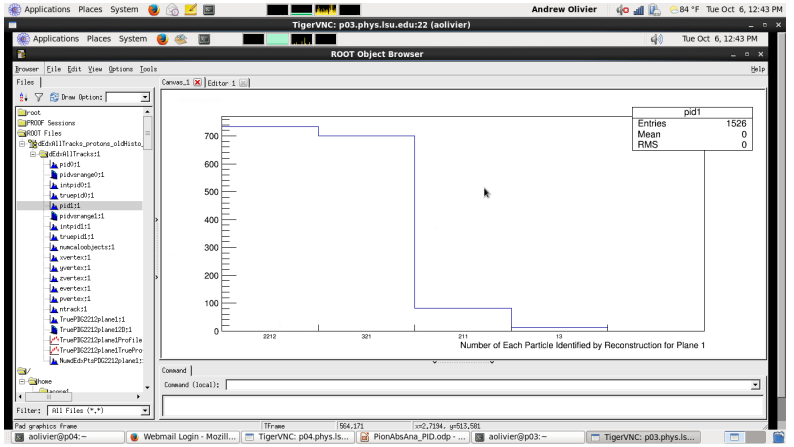
PID: Original Configuration



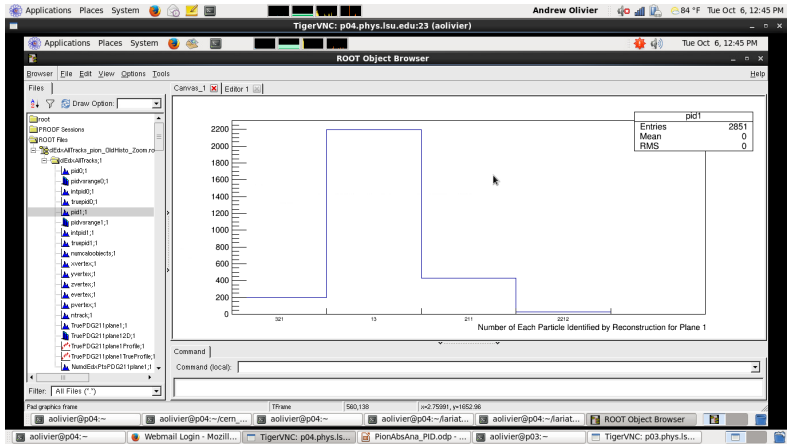
PID: Efficiencies for Various PDG Codes



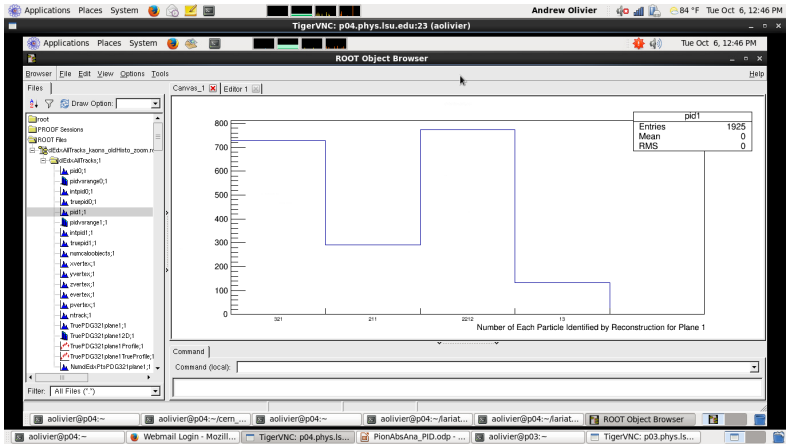
Muon



Proton



Pion

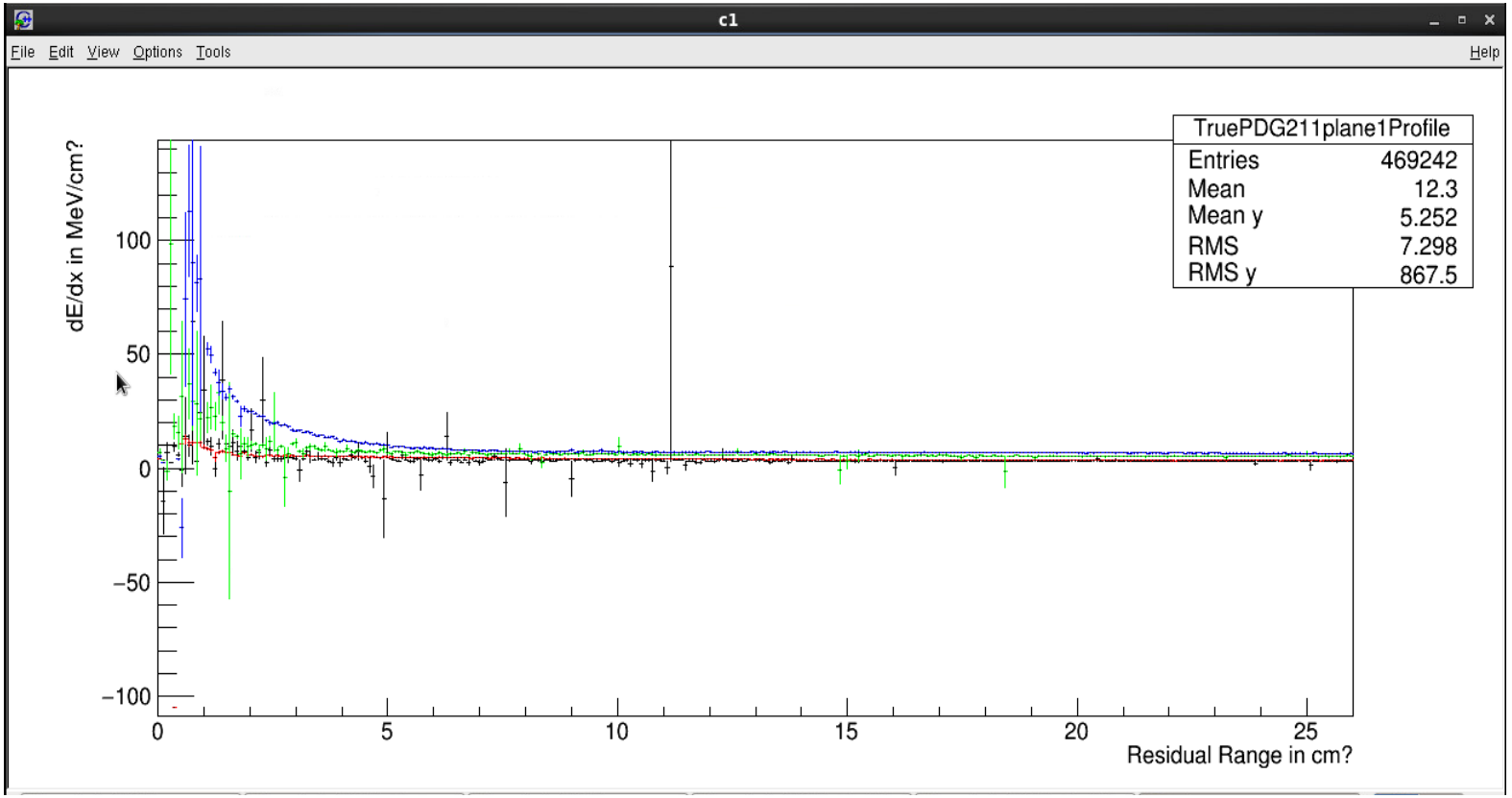


Kaon

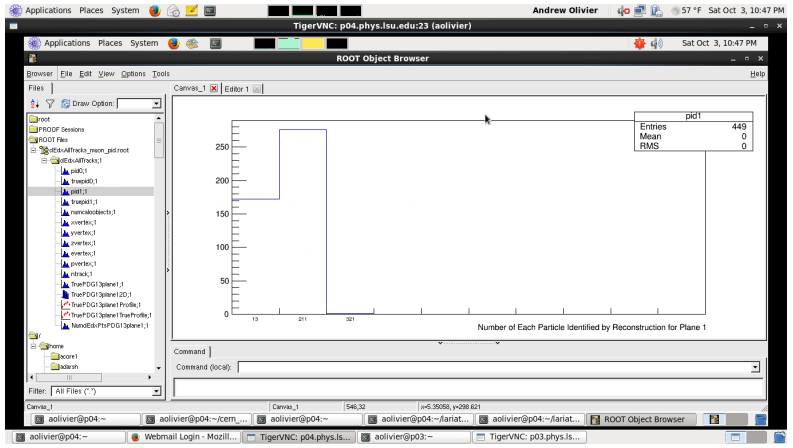
Generating a LArIAT dE/dx Versus Residual Range Plot

- Used MC samples of 5000 protons, negative muons, positive pions, and positive kaons
- Mean dE/dx values larger for new plots
- Using standard configuration of TProfile to calculate error bars
- How were plots in lardata made?

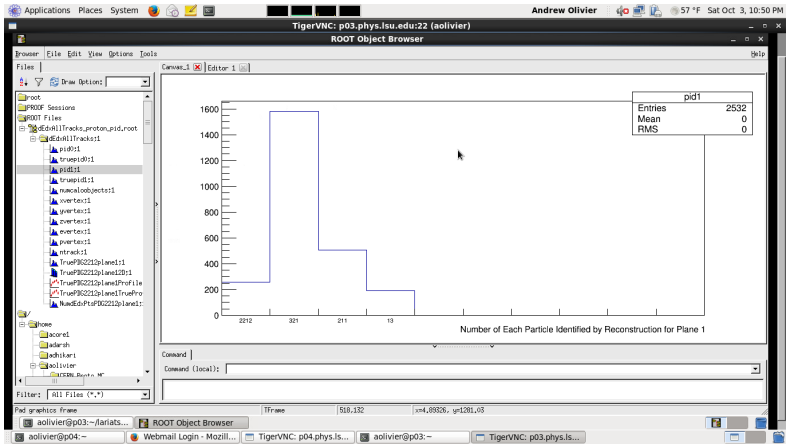
Reconstructed dE/dx Versus Residual Range Plots



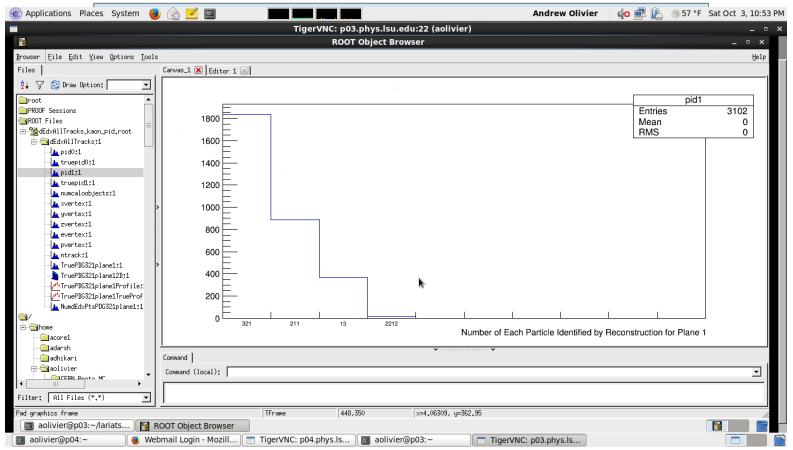
PID Effieciencies with Recostructed Plots



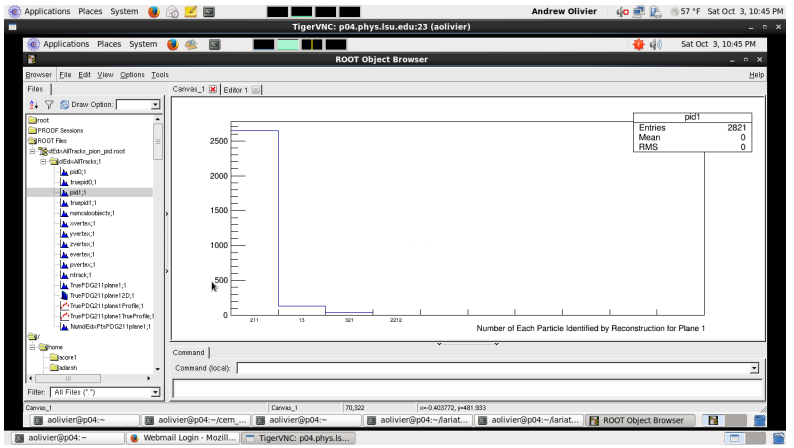
Muon



Proton

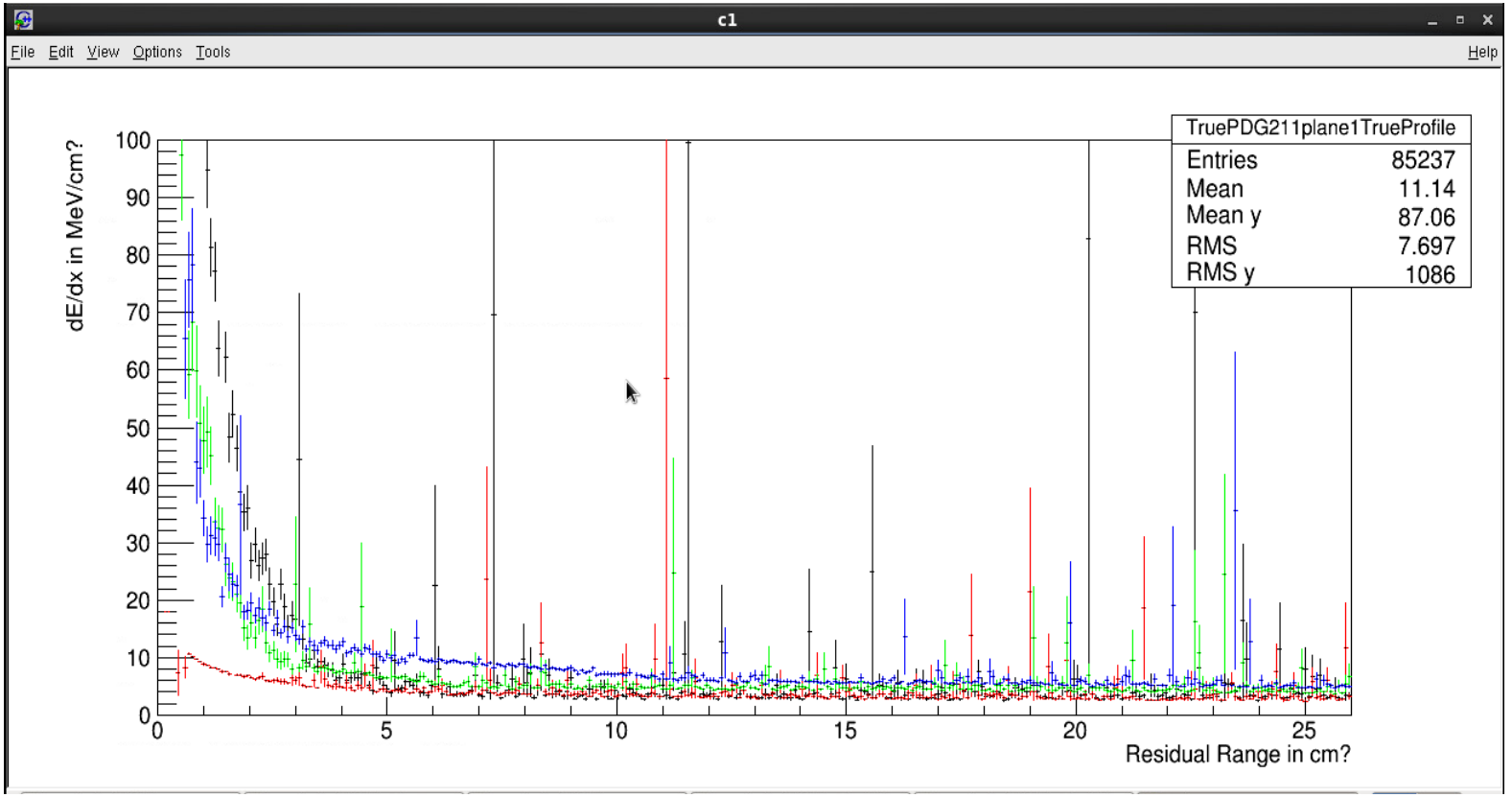


Kaon

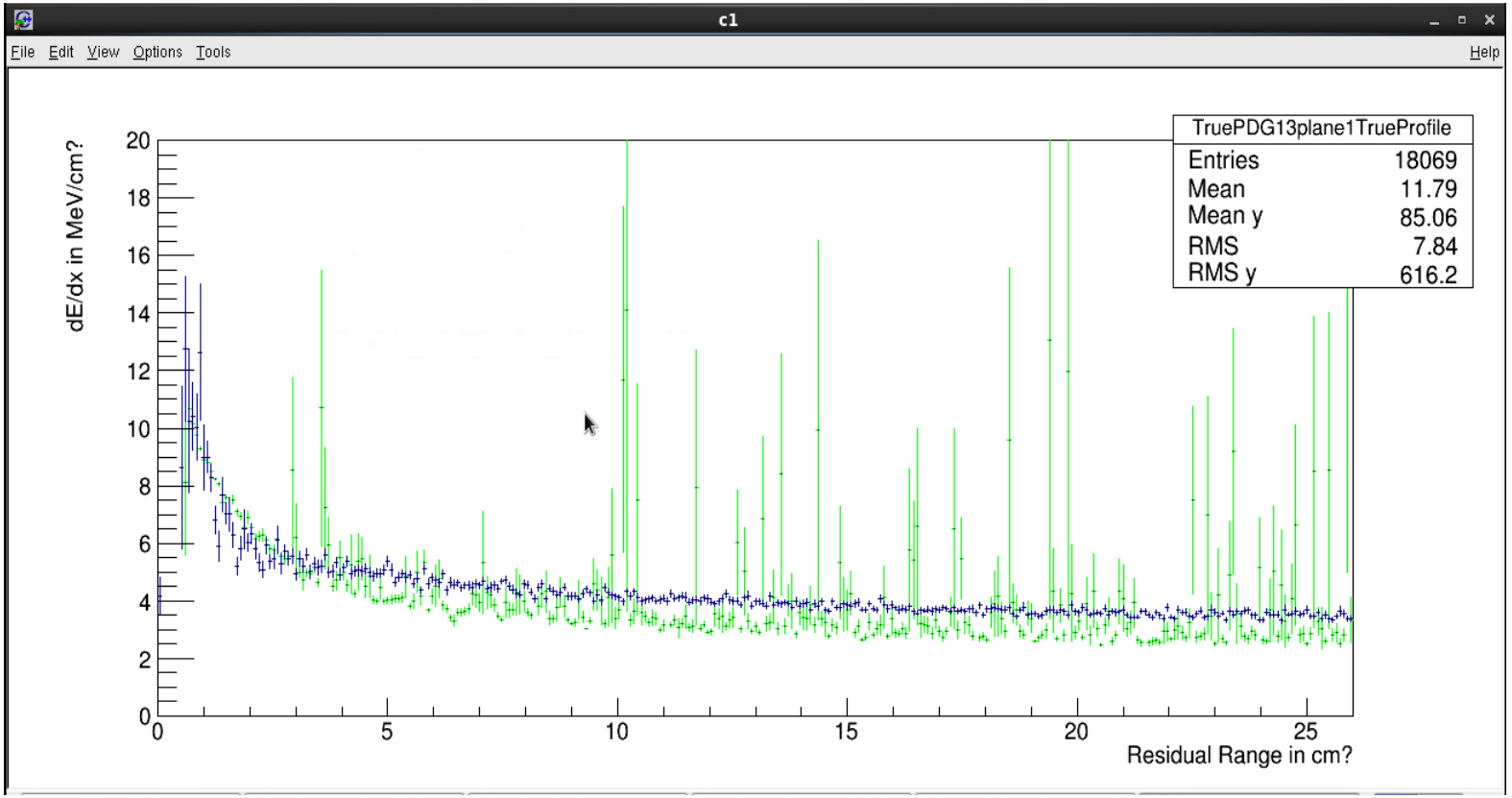


Pion

True dE/dx Versus Residual Range



Muon dE/dx Versus Range: True and Reconstructed



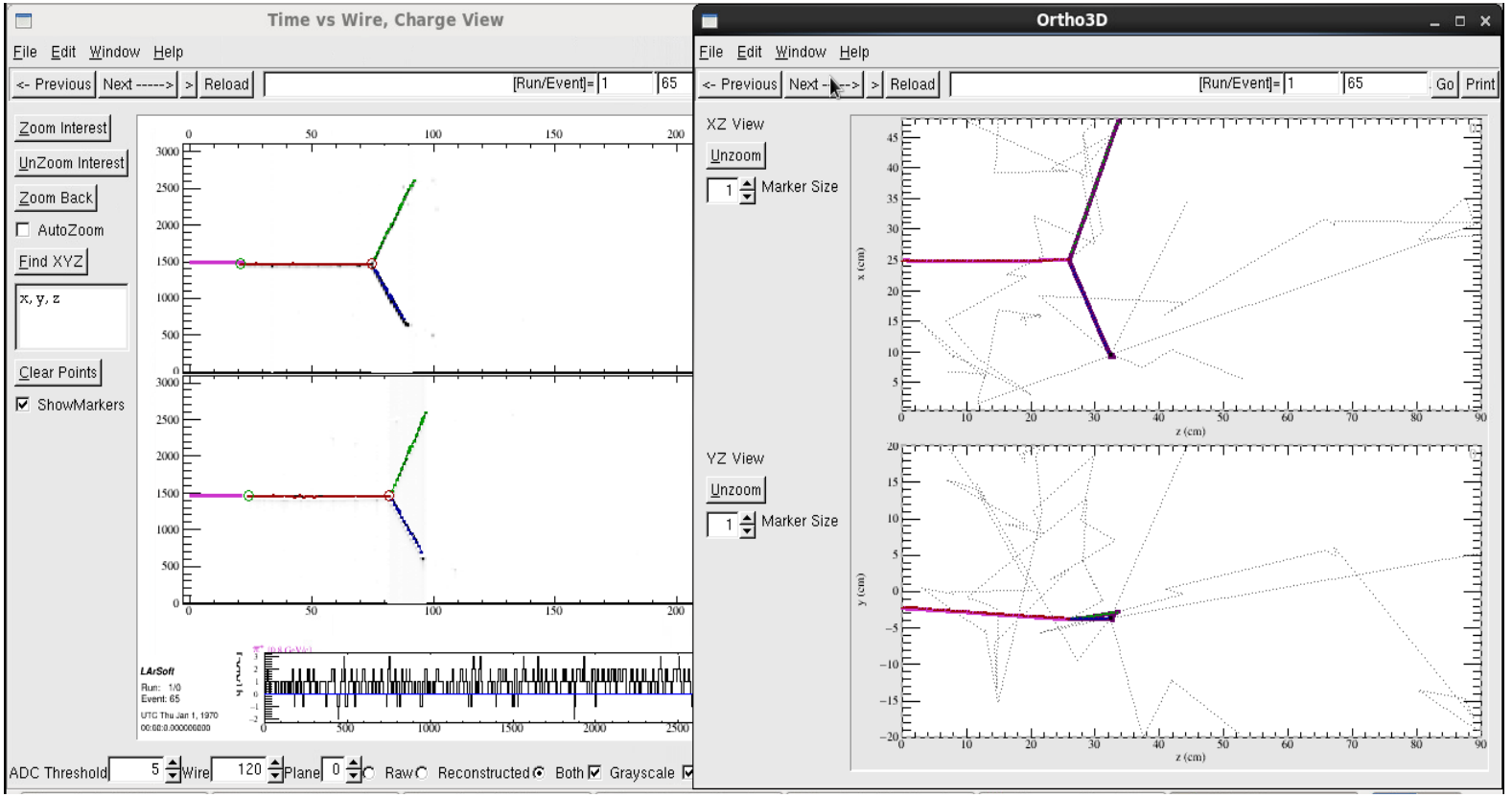
Blue: Reconstructed

Green: True

MC Sample Signal Identification

- MC topology filter module in local feature branch
  - Requires only particles from a user-supplied list as secondaries
    - Can require certain numbers of each particle
    - Currently ignores nuclear debris
  - Requires containment of secondary vertex
  - Tested only with pion absorption, but may be applicable to other analyses

MC Signal Sample Identification Example



Conclusions and Future Work

- More efficient PID needed
  - Calorimetry seems OK
  - New plots based on MC samples?
    - Currently running lower energy samples to fill in small residual range points
    - How were larsoft_data histograms generated?
- Finish implementing absorption cross section analysis module
  - Requires PID
  - Shower identification
  - Vertices associated with incoming track?
- Test analysis module efficiency on signal using filter and purity on full sample
- Extend analysis to calculate pion absorption cross section from beam data